Utilizing Light-Emitting Diodes in Today's Energy Conscious World

LEDTRONICS, INC.®
THE FUTURE OF LIGHT

23105 Kashiwa Court, Torrance, CA 90505
Phone: (800) 579-4875 or (310) 534-1505
Fax: (310) 534-1424
E-mail: webmaster@ledtronics.com
Website: www.ledtronics.com

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Utilizing Light-Emitting Diodes (LEDs) in Today’s Energy Conscious World

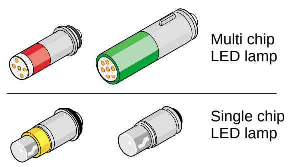


Figure A

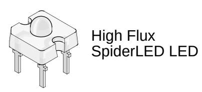


Figure A.1

Figure B

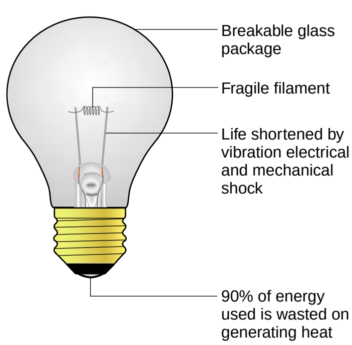


Figure C

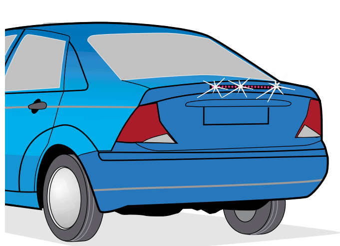


Figure D

Once limited to simple status indicators, Light Emitting Diodes (LEDs) now play prominent roles in back lighting, panel indication, decorative illumination, emergency lighting, animated signage, etc.... The emergence of LEDs as a viable alternative to incandescent lighting can be attributed to new manufacturing technologies, packaging innovations and an increasing number of colors. These factors along with the growing awareness of the advantages of LEDs (e.g., a life span measured in years not hours, vivid sunlight-visible colors and low power requirements) have engineers, product designers, purchasing agents and component vendors viewing LEDs in a whole new light.

LED Benefits

For many applications LED lamps are superior to incandescent lighting. So why is it that in tens of millions of switches, indicators, control panels, signs, annunciators, displays, decor lights and dozens of other applications, design engineers still specify incandescent technology? It might be that they’re just a few years behind what’s really happening in LED illumination.

Although advances made in LED technology in the past few years have dramatically broadened the applications for these rugged little light sources, it wasn’t that long ago that red was the only “daylight-visible” colored LED. And that wasn’t the only thing limiting their use!

Unlike incandescent bulbs that give off the full spectrum of light in a spherical pattern, LEDs emit a focused beam of a single wavelength (color) in only one direction, in a variety of angles. For many applications, such as indicators or switch illuminators, this is not a problem, but it took the development of multi-chip arrays **(*see Figure A*)** and high-flux LED chips **(*see Figure A.1*)** to begin to achieve the effect of an incandescent filament.

Major advancements in LED technology have taken place in recent years such as development of new “doping” technologies that increase LED light output by as much as 20 times over earlier generations, and allow the production of daylight-visible LEDs in virtually any color of the spectrum. In addition to red, yellow, and amber/orange, LEDs are now available in many colors from leaf green to ultra blue. Even white light, long thought to be an impossibility, is now available in three different shades as a light-emitting diode. **(*see Figure B*)**

(see* What White-Light LEDs Can Illuminate and How They Can Be Used *in this publication.)

The efficiency of LEDs is most apparent in applications requiring color. Light from a typical incandescent bulb must be filtered so that only light from a particular part of the spectrum (e.g., red, amber or green, etc...) for example—is visible. While LEDs deliver 100 percent of their energy as colored light, incandescent bulbs waste 90 percent or more of their energy in light blocked by the colored lens or filter. Incandescent bulbs also waste 80 percent to 90 percent of their energy on heat generation to reach the temperature for which (Kelvin scale) they are designed. **(*see Figures C & R.1*)**

With LEDs you get a more color-controlled monochromatic intense light. Observe the color difference between the third brake light on many modern cars. One third of all third (center brake light) brake lights are red LED clusters. Many car manufacturers frequently use LEDs because the third brake light is often inaccessible and replacement is essentially impossible. The next time you’re in traffic look for one of these and notice how much more vivid red this light is than that emerging from standard—filtered—incandescent taillights. **(*see Figure D*)**

The point is that what was once a fairly marginal light source isn’t marginal any more. In many applications, LEDs exceed the energy available from incandescent bulbs and offer significant additional benefits making LED clusters and lamps as friendly to the environment as they are to the operating budget.

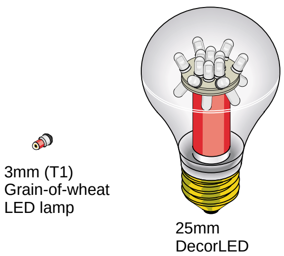


Figure E

LEDs with standard lamp bases were once only competition for tiny miniature and subminiature bulbs called the T1 or 3 mm "grain-of-wheat" bulbs. Today LED lamps come in a wide variety of standard lamp bases, in sizes ranging from the grain-of-wheat T1 (3 mm) to medium-screw 25 mm G30 sized bulbs and larger. LED lamps are rugged durable, daylight visible and—a blessing to overworked maintenance personnel—have a life span far exceeding that available from current incandescent technology. **(*see Figure E*)**

Obviously, the material cost of the incandescent bulb itself is inconsequential—the real cost is in lost production, wasted labor and energy. What really costs is to have a machine down or perhaps an entire line—with skilled operators idle. That's not to mention the labor costs associated with the maintenance worker who could spend their time on more productive projects rather than changing light bulbs.

Depending on what it costs you to have a machine down and pay an operator and maintenance worker—even if it's just for a quarter of an hour—the real cost of relamping incandescent bulbs can be astronomical. **(*see Figure F*)**

Figure F

LED Technology

The basic LED consists of a semiconductor diode chip mounted in the reflector cup of a lead frame that is connected to electrical (wire bond) wires, then encased in a solid epoxy lens. LEDs emit light when energy levels change in the semiconductor diode. This shift in energy generates photons, some of which are emitted as light. The specific wavelength of the light depends on the difference in energy levels as well as the type of semiconductor material used to form the LED chip. **(*see Figure G*)**

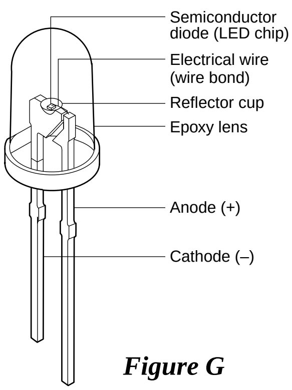


Figure G

LEDs are color-controlled monochromatic, narrow bandwidth lux producing devices. Depending on how the LED chip is packaged determines the beam (narrow or wide) angle. Things that effect the beam angles are: shape of the reflector cup, size of the LED chip, epoxy lens shape, and the distance between the LED chip and the top of the epoxy lens.

LEDs are available in both visible and infrared wavelengths. Infrared LEDs reach wavelengths of 830 nanometers to 940 nm. Visible colors include red, yellow, orange, amber, green, blue/green, blue, and white. These fall into the spectral wavelength region of 400 nm to 700 nm. The colored light of an LED is determined exclusively by the semiconductor compound used to make the LED chip and independent of the epoxy lens color.

Molding different LED chips within a common housing creates (as an example, Red, Green and Blue chips, RGB LEDs) multicolor LEDs. Applying positive and negative voltages turn on each color. **(*see Figures H & H.1*)**

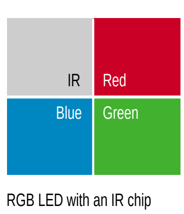


Figure H

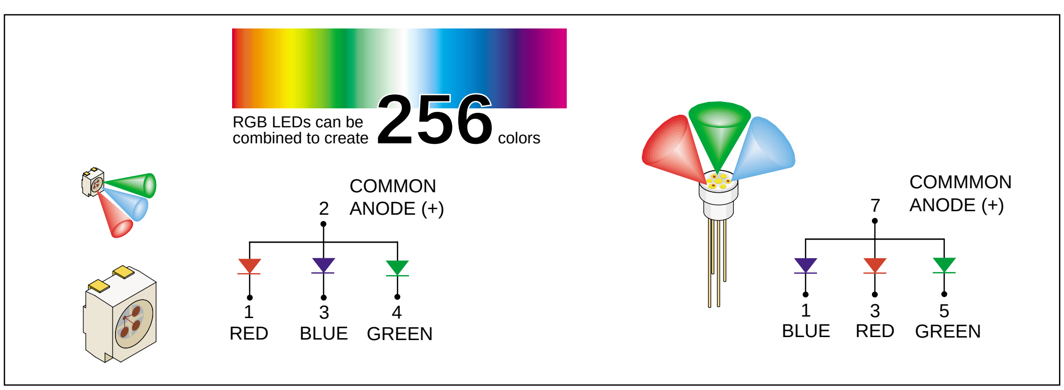
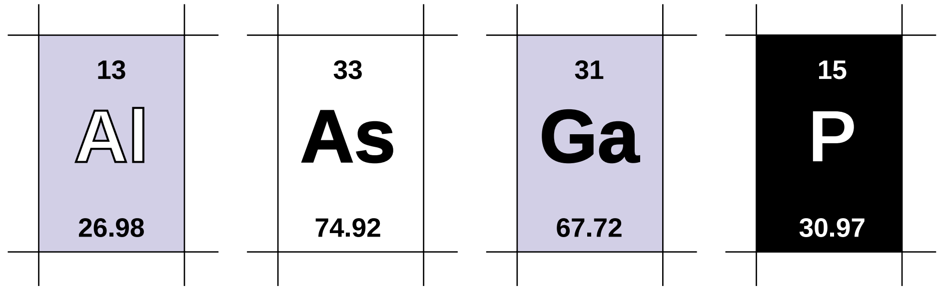


Figure H.1

Red LEDs—Color, Brightness and Chemistry



Infrared Original Type
Gallium Arsenide (GaAs)

A spectral peak at 940 nm makes this LED invisible to the human eye. Voltage drop is 1.2 – 1.3 volts. Drive current is 50mA.

High-Efficiency Infrared
Gallium Aluminum Arsenide (GaAlAs) 880 nm & 940 nm

Gallium Aluminum Arsenide accounts for the higher efficacy as compared to the Gallium Arsenide LED. Also, this LED features a shorter peak wavelength—880 nm. Voltage drop is around 1.4 volts. Drive current is 50 mA. Because the spectral output extends into the low 800s nm (wavelengths visible to the human eye) this LED is dimly seen in a dark room.

Original High-Efficiency Red (630 nm)
1960 *- Gallium Phosphide doped with Zinc & Oxygen (GaP: Zn, O)*

This LED is efficient (1 to maybe 2 lumens/watt) at a few milliamps or less. At 20 mA, it's about 2 – 3 times as efficient as the original formula visible red LED.

Color varies with current. At 0.5 – 1.0 mA the LED output is nearly pure red, at higher currents it appears more orange. If the lamp is not tinted red, the emitted light color ranges from orange to yellowish-orange at 30 mA.

Spectral output is a broad band, nominally peaking at 697 nm and maybe only peaking that far out in the red at really low currents. At higher currents, there is a very weak secondary spectral band in the blue-green band around 510 nm.

Maximum drive current is usually 30 mA, but this LED has a noticeably nonlinear light output that increases less than proportionately with current above a few milliamps. Voltage drop is around 1.9 volts.

Original-Formula Visible Red
1968 *- Gallium Arsenide Phosphide (GaAsP) on a Gallium Arsenide (GaAs) Substrate*

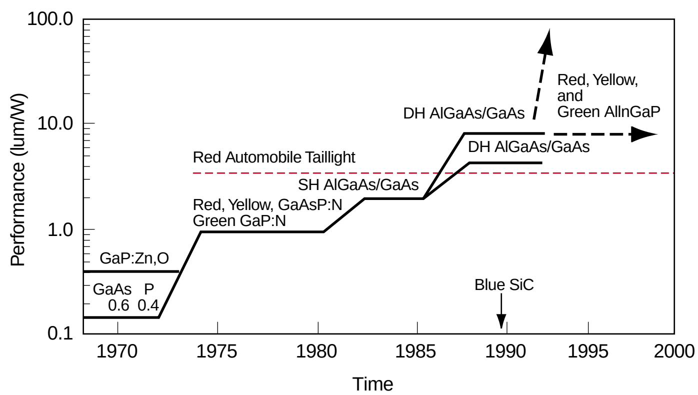
Spectral output peaks around 660 nm. Color is a pure red. Efficacy is low. Most LEDs using this technology need a maximum continuous drive current of 50 mA, but at a typical current of 20 mA it is reasonably bright. Efficacy is maximized at currents of 20 mA and up. Voltage drop is 1.6 – 1.75 volts.

Ultra Brightness Red (660 nm)
1980 - Gallium Aluminum Arsenide Phosphide (GaAlAsP)

Overall luminous efficacy of this LED is, at best, 9 lumens/watt. Output peaks between 650 nm and 670 nm. Color is pure red to laser red with a dominant wavelength (monochromatic light of matching color) in the 640s but can range from about 635 to about 650 nm. Efficacy maximizes at currents near 20 – 25 mA. Voltage drop at 20 mA is 1.8 to 1.9 volts. Maximum rated drive current is 30 mA but sometimes 50 mA. Dimly glows at 1.5 volts.

High-Efficiency Red, and Orange
1990 - Gallium Arsenide Phosphide (GaAsP) on Gallium Phosphide (GaP) substrate

This was the first non-low-current, high-efficiency red LED. The Gallium Phosphide substrate is transparent to the emitted light and Gallium Arsenide is not. This is one reason why this LED is more efficient than the original-formula red. Color is orange-red with a dominant wavelength around 620 nm. A slight variation of this has a dominant wavelength usually around 610 – 615 nm and is considered orange. Drive current is 5 – 20 mA. Maximum current is 30 mA. Voltage drop at 20 mA is around 1.9 volts.



Type	Color (peak wavelength, nm)	Typical Performance (lum/W)
GaAsP	Red (650)	0.15
GaP:Zn,O	Red (700)	0.4
GaAsP:N	Red (630)	1
GaAsP:N	Yellow (585)	1
GaP:N	Yellow-Green (565)	2.5
GaP	Pure Green (555)	0.6
AlGaAs	Red (650)	2
	Red (650)	4
	Red (650)	8
AlInGaP	Orange (620)	20
	Yellow (585)	20
	Green (570)	6
SiC	Blue (480)	0.04

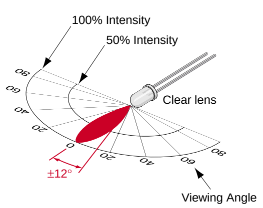


Figure I

LED Lens Configurations:

1. Clear lenses have no tint or diffusion, produce the greatest light output and narrowest viewing angle. They are designed for applications that require very high intensity but need to be colorless in the off-state. **(*see Figure I*)**

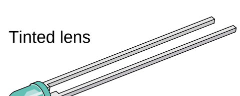


Figure J

2. Tinted lenses are used to indicate what the LED color will be when in the on-state. **(*see Figure J*)**

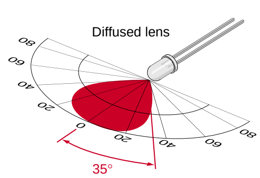


Figure K

3. Diffused lenses have tiny glass particles embedded in the epoxy. This spreads the light to a viewing angle of approximately +/-35 degrees from center. These LEDs are often used for applications in which the LED protrudes through a hole in the front panel of electronic equipment. **(*see Figures K & L*)**

4. Non-diffused lenses that do not have glass particles in the epoxy produce a narrow viewing angle of +/-12 degrees from the center. They are often used in backlighting applications in which the LED is focused on a translucent window in the front of a panel. **(*see Figure I*)**

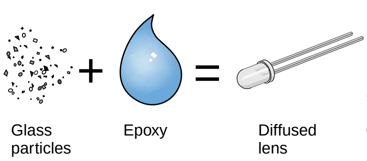


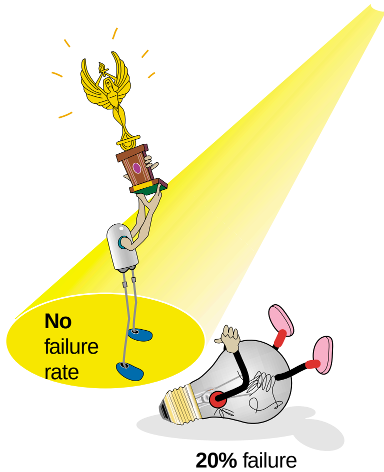
Figure L

Other viewing factors include the LED's epoxy lens shape, shape of the reflector cup, size and the distance from the LED to the nose of the epoxy lens. The closer the LED is positioned to the nose of the epoxy lens, the wider the viewing angle.

A Comparison Between Incandescent Lamps and LEDs

LEDs use a fraction of the power (80% – 90%) required by conventional filament bulbs. Solid-state design allows LEDs to withstand shock, vibration, frequent switching (electrical on and off shock) and environmental (mechanical shocks) extremes without compromising their famous long life—typically 100,000 hours or more.

Incandescent lights heat a metal filament that radiates light inside a glass bulb. They radiate white light, which consists of a wide spectrum of electromagnetic radiation. Incandescents generate high-intensity light for a short operating lifetime and are susceptible to damage from shock, vibration and temperature extremes. **(*see Figure C*)**



NYSEG
New York State Electric & Gas Corp.

Figure M

An Example: In 1995, New York State Electric & Gas Corporation (NYSEG) entered into a joint testing of LED bulbs. The basic agreement called for NYSEG to test the LED lamps in a specific substation and give a report shortly after installation and again at the end of the test period. LEDtronics, Inc. supplied the bulbs and they were installed in February 1996. The station uses over 100 bulbs.

Each incandescent bulb in the station was turned on and off then back on once before removal. Twenty percent of the incandescent bulbs failed. The same process was used with the LED lamps. None failed.

As of December 1997 (22 months later), NYSEG experienced no failure of any LED lamp at the station even though the bulbs have been turned off and on several times during the period. (Note: NYSEG recorded all incandescent bulb failures under normal operations at a comparable station and had approximately a 25 percent failure rate.) Both the LED bulb life, brilliance, and view angle proved to be acceptable to field personnel at NYSEG. **(*see Figure M*)**

NYSEG believes that even though the initial installed cost for LED lamps is much greater than incandescent bulbs, over the life of any substation, the cost of LED lamps for NYSEG's purposes will be much less than incandescent bulbs. There are less storage needs, reduced replacement time and much less current drain on the substation batteries. In addition, there should be less frustration during testing periods where bulbs are a key to what devices are in or out of service.

Cost Justification for LED Lamps

As an example of the cost savings attributed to using LED lamps, first choose the value that most closely represents your per-hour cost of having a machine down. Then figure in the approximate cost-per-hour of your maintenance labor rate and the cost-per-hour of the machine operator. The results are the approximate savings an LED lamp can offer in its ten-year life span.

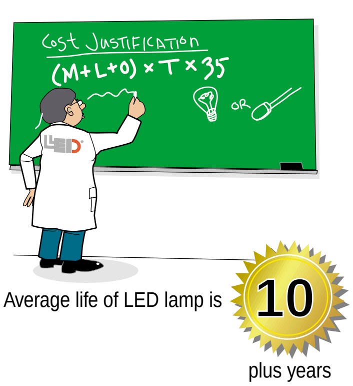


Figure N

If you want to do the math based on your own figures, here's the formula we used. (M = the cost of machine downtime per hour; L = the cost of maintenance labor per hour; O = the cost of operator labor, per hour; and T = the time it takes to change a bulb [we used 25 hours, by the way, but the actual time could be different].) **(*see Figure N*)**

(M+L+O) x T x 35 = Cost of conventional lamps for 10 years **(*see Figures O.1, O.2, O.3*)**

To get the total costs, of course, you'll have to add in the number of LED lamps that you are replacing and the energy savings that you will achieve over ten years (average life of the LED lamp).

Machine Downtime @ $100/Hr.

Maintenance Labor	**$65**	$1575	$1619	$1750	$1881	$2013
	$50	$1444	$1488	$1619	$1750	$1881
	$35	$1313	$1356	$1488	$1619	$1750
	$20	$1181	$1225	$1356	$1488	$1619
	$15	$1138	$1181	$1313	$1444	$1575
		$15	**$20**	**$35**	**$50**	**$65**
		Operator Labor				

Figure O.1

Machine Downtime @ $500/Hr.

Maintenance Labor	**$65**	$5075	$5119	$5250	$5381	$5513
	$50	$4944	$4988	$5119	$5250	$5381
	$35	$4813	$4856	$4988	$5119	$5250
	$20	$4681	$4725	$4856	$4988	$5119
	$15	$4638	$4681	$4813	$4944	$5075
		$15	**$20**	**$35**	**$50**	**$65**
		Operator Labor				

Figure O.2

Machine Downtime @ $1000/Hr.

Maintenance Labor	**$65**	$9450	$9494	$9625	$9756	$9888
	$50	$9319	$9363	$9494	$9625	$9750
	$35	$9188	$9231	$9363	$9494	$9625
	$20	$9056	$9100	$9231	$9363	$9494
	$15	$9013	$9056	$9188	$9319	$9450
		$15	**$20**	**$35**	**$50**	**$65**
		Operator Labor				

Figure O.3

Effect of Rise in Ambient Temperature on Based LED Lamp's Longevity

The rise in ambient temperature effects a Based LED lamp's longevity and, as a result, the operating current (or power dissipation) for a Based LED lamp must be adjusted. For reference purposes, we will use a Based LED lamp (p/n BF321CR3K-24V-BP) designed for 24 nominal voltage and 28 maximum operating AC or DC voltage. All components in the subject Based LED are designed to operate in the 35°C – 45°C range with the ambient temperature of 25°C.

General Rule for Operating the Based LED Lamps in an Environment Where the Ambient Temperature is Above the Range Specified for the Based LED

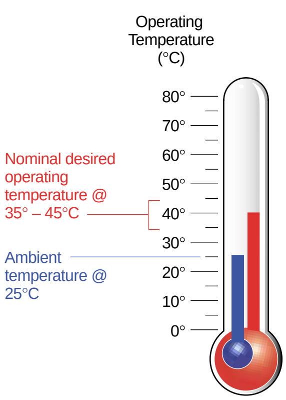


Figure P

Since LEDs are current driven, each degree the ambient temperature rises it affects the Based LED's (including its components) operating temperature. In order to maintain the projected longevity (100,000 hours) of the Based LED, the Based LED and its components should be redesigned to operate within the nominal desired operating temperature range of 35°C – 45°C. This can be accomplished by derating the operating current (mA) of the Based LED by 0.3 mA per each degree rise in ambient temperature above nominal (25°C). For example: When the ambient temperature is specified around 25°C but rises to 55°C, the Based LED experiences an increase of 30°C in its operating temperature. As a result the LED's operating current range should be reduced by 10 mA (70°C – 40°C x 0.3) to compensate for the rise in ambient temperature and to maintain the expected longevity of the Based LED. Similarly, if the operating current of the Based LED lamp is not derated to compensate for the rise in ambient temperature, the Based LED at an ambient temperature of 55°C/operating temperature 70°C is actually operating at a current 10 mA higher than it was designed to accommodate. (The maximum current for most LEDs is 20 mA.) This reduces the Based LED's expected longevity. ***(see Figure P)***

Conclusion

Operating the Based LED lamps at a higher operating temperature than for which it was designed adversely affects the longevity of the LED lamp. However, without extensive life-cycle testing on the Based LED lamp, it is impossible to determine the precise number of hours by which the Based LED lamp's longevity will be reduced.

What White-Light LEDs Can Illuminate and How They Can Be Used

While the introduction of white-light LEDs has increased interest in using LED lighting, they have raised an equal number of questions concerning what white-light LEDs can and cannot illuminate and how they can be used. To understand the potential of white-light LEDs, it is helpful to examine the two methods used to produce white light from LEDs.

White light from LEDs can be produced by two methods: (1) combining red, green, and blue LED chips in one discrete package or cluster LED lamp, and (2) coating blue Indium Gallium Nitride (InGaN) LED chips with phosphorus. The technique of mixing red, green and blue (RGB) LED chips is used in signage because RGB LEDs can be combined to create 256 colors making it a cost-effective and efficient solution. If a lighting application requires a rainbow of colors from a single-point light source then a RGB LED is the answer.

In the second method, blue light from an InGaN LED chip filters through the phosphorus and generates a cool-white or fluorescent light appearance. InGaN technology results in superior reliability and color integrity. InGaN LEDs would be used, for example, in elevator panel lights because illumination of only one color is needed. The brightness and color purity of InGaN-white LEDs depend on the amount of phosphorus coating. Three shades of InGaN-white LEDs exist: 1) cool white, 2) pale white and 3) incandescent white. Cool white has the least amount of phosphorus, incandescent white the most and pale white is somewhere between the two. Cool white is the brightest, incandescent the dimmest and pale white holds the middle ground.

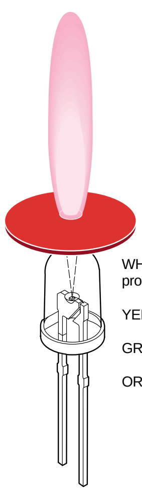


Figure Q

Previously, the lack of white-light LEDs has limited the integration of LEDs into a wide range of applications; however, now, the misconception exists that InGaN-white LEDs can illuminate a lens of any color thereby simplifying lighting requirements and designs. Wrong! Since the color red is not represented in the white LED, white LEDs can only be used behind a clear or milky white lens or panel. Place a white LED behind a red lens and the light produced is a pink color, a yellow lens turns a lemon-lime, green lens shifts to aqua and orange lens becomes yellow. To maintain accurate and brilliant colors, it is imperative to match the LED color with the lens color. In short, white LEDs made from a blue chip cannot be used as a general backlighting light source for different colored lenses and panels. **(*see Figure Q*)**

LED or Incandescent? What's Brighter? What's Better?

Each light source has merits and each performs well when used in a suitable environment. The lumen-per-watt, the SI unit commonly used for measuring the total amount of light emitted by a light source per the energy input, does not accurately reflect the true efficacy of LED light sources. An LED is a directional light source and emits little or no spherical light, whereas lumen-per-watt takes into account all light emissions, including spherical, from a light source and not just what is actually accomplishing the required illumination task.

Today, for general lighting (e.g., living areas, factory floors) applications an incandescent bulb generates more visible light-per-watt than an equivalent LED, making an incandescent better suited for this type of job. However, it's in color-specific and power-critical applications (e.g., third brake lights, display panels, industrial controls and traffic signals) that energy-efficient LEDs really outshine incandescents.

An LED is a solid-state semiconductor device that converts almost all of its electrical energy directly into a particular color wavelength of light (measured in nanometers), resulting in high efficacy. (The composition of the materials in the semiconductor chip determines the wavelength and, therefore, the color of the light. Lenses, reflectors and diffusers can be integrated into the package to achieve desired spatial radiation characteristics.)

For example: Compare a red LED to a red-filtered incandescent lamp. A red LED might be as much as 10 times more visible than the red-filtered incandescent lamp because the red filter reduces the incandescent's light output. Unlike an LED, which is a monochromatic light and doesn't need to be filtered, an incandescent emits a full-spectrum light and, therefore, requires a filtering system to produce light of a specific color. (Placed under a lens, an LED lamp cluster can suffer a 20% – 30% reduction in brightness depending on the color and thickness of the lens. The lighter the lens pigmentation the brighter the LED lamp appears.) Additionally, most of an incandescent's energy (80% – 90%) is wasted in the generation of heat that is needed to achieve the Kelvin scale of light wavelength color the incandescent is trying to produce.
(*see Figures R & R.1*)

To more accurately quantify and compare efficacy of an LED to an incandescent, you must consider the following: specific application, luminance, lens type and intensity.

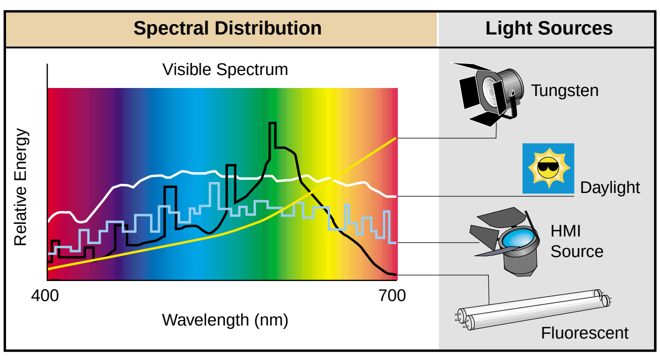


Figure R

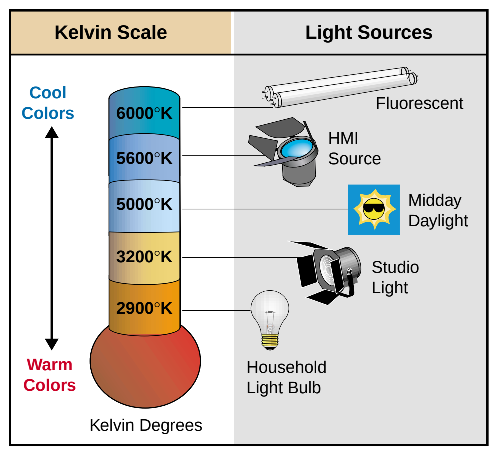


Figure R.1

Wattage of LED Lamps

When evaluating LEDs, customers mistakenly ask for the wattage of LED lamps when they really want to know how bright the lamps are. This common error can be attributed to the prominence given to the wattage (power consumption) on the packaging of incandescent light bulbs and other electrical devices. Through experience, consumers have developed expectations about the how bright a 20-, 40-, 60- or 100-watt bulb should be and they apply that frame of reference to LED lamps. To clarify the relationship of watts to light output and LED bulbs, it is important first to define the correct terminology.

Watt measures the amount of power that the light uses, not how bright the lamp's output is. Brightness is measured in Lumens. Most light bulb packages list the lumens per bulb as well as the wattage.

LEDtronics provides this information on most of our LED bulbs. BeaconLED and DecorLED data sheets list the energy used (Watts) and light output (Lumens/sq ft.). Other data sheets give the light output rating in millicandela (mcd), which is another common unit of measurement used for LED light output.

The conversion from Watts to Lumens at any other wavelength involves the product of the power (Watts) and the value at the wavelength of interest. The wavelength of 555 nm is used as the benchmark because the human eye is most sensitive to the yellowish-green part of the spectrum.

1 watt = 683.0 lumens @ 555 nm

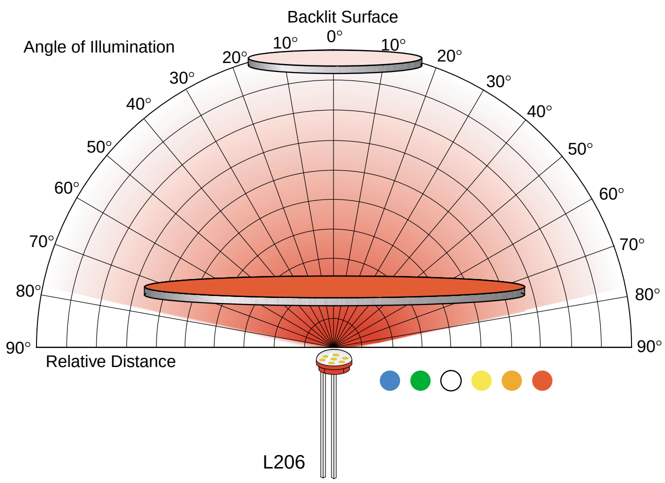
Wavelength Nanometer	Luminous Efficiency	Lumen (lm) / Watt (W) Conversion	Wavelength Nanometer	Luminous Efficiency	Lumen (lm)/Watt (W) Conversion
380	0.000039	0.027	570	0.952000	650.216
390	0.000120	0.082	580	0.870000	594.210
400	0.000396	0.270	590	0.757000	517.031
410	0.001210	0.826	600	0.631000	430.973
420	0.004000	2.732	610	0.503000	343.549
430	0.011600	7.023	620	0.381000	260.223
440	0.023000	15.709	630	0.265000	180.995
450	0.038000	25.954	640	0.175000	119.525
460	0.060000	40.980	650	0.107000	73.081
470	0.090980	62.139	660	0.061000	41.663
480	0.139020	94.951	670	0.032000	21.856
490	0.208020	142.078	680	0.017000	11.611
500	0.323000	220.609	690	0.008210	5.607
510	0.503000	343.549	700	0.004102	2.802
520	0.710000	484.930	710	0.002091	1.428
530	0.862000	588.746	720	0.001047	0.715
540	0.954000	651.582	730	0.000520	0.355
550	0.994950	679.551	740	0.000249	0.170
555	1.000000	683.000	750	0.000120	0.082
560	0.995000	679.585	760	0.000060	0.041
			770	0.000030	0.020

Keep in mind that unlike incandescent light bulbs that illuminate in a 360-degree spherical pattern regardless of the shape of the bulb, LEDs depend on the shape and composition of their lenses and package structure to direct the light where it is needed. LEDs inherently emit a focused beam of a single wavelength in only one direction. Depending on how the LED chip is packaged determines the beam (narrow or wide) angle. Common things that effect the beam angle are the shape of the LED reflector cup, size of the LED chip and how close the LED chip is to the top of the epoxy lens. In conclusion, besides Watts and Lumens, the specific application, luminance, lens type and intensity must be considered to ascertain the legitimate efficacy of LEDs.

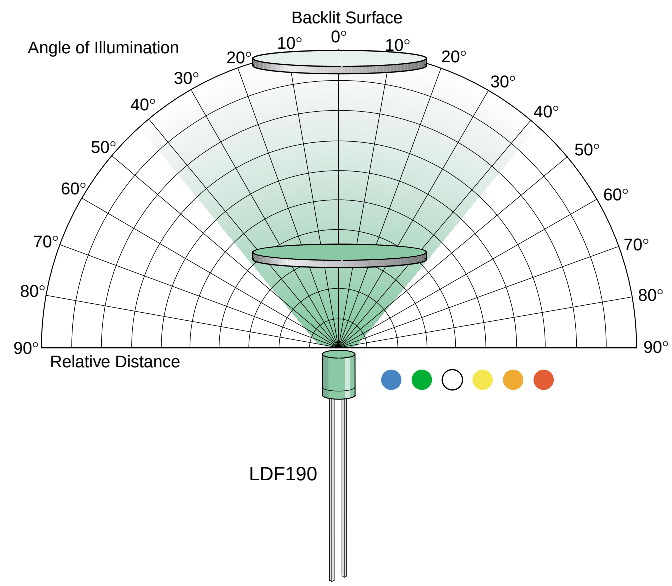
LED Color Chart

LED Chip Code	Wavelength nm	Color Name	Fwd Voltage Vf @ 20mA	Intensity 5mm LEDs	Viewing Angle	LED Dye Material
IR941	940	Infrared	1.5	16mW @ 50mA	15°	GaAIAs/GaAs - Gallium Aluminum Arsenide/ Gallium Arsenide
IR881	880	Infrared	1.7	18mW @ 50mA	15°	GaAIAs/GaAs - Gallium Aluminum Arsenide/ Gallium Arsenide
IR851	850	Infrared	1.7	26mW @ 50mA	15°	GaAIAs/GaAIAs - Gallium Aluminum Arsenide/ Gallium Aluminum Arsenide
R3KF	660	Ultra Red	1.8	2000mcd @ 20mA	15°	GaAIAs/GaAIAs - Gallium Aluminum Arsenide/ Gallium Aluminum Arsenide
R3/R4/R5	635	High Eff. Red	2.0	200mcd @ 20mA	15°	GaAsP/GaP - Gallium Arsenic Phosphide /Gallium Phosphide
E3K	633	Super Red	2.2	3500mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
O3K/O6K	620	Super Orange	2.2	4500mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
O3KF	612	Super Orange	2.2	6500mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
O4/O5	605	Orange	2.1	160mcd @ 20mA	15°	GaAsp/GaP - Gallium Arsenic Phosphide /Gallium Phosphide
Y3KF	595	Super Yellow	2.2	5500mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
Y3KH	592	Super Pure Yellow	2.1	7000mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
Y3/Y4/Y5	585	Yellow	2.1	100mcd @ 20mA	15°	GaAsp/GaP - Gallium Arsenic Phosphide /Gallium Phosphide
IW2K	4500K	Incand White	3.6	2000mcd @ 20mA	20°	SiC/GaN - Silicon Carbide/Gallium Nitride
PW4K	6500K	Pale White	3.6	4000mcd @ 20mA	20°	SiC/GaN - Silicon Carbide/Gallium Nitride
CW6K	8000K	Cool White	3.6	6000mcd @ 20mA	20°	SiC/GaN - Silicon Carbide/Gallium Nitride
LY1K	574	Super Lime Yellow	2.4	1000mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
G1K	570	Super Lime Green	2.0	1000mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
G3/G4/G5	565	High Eff. Green	2.1	200mcd @ 20mA	15°	GaP/GaP - Gallium Phosphide/Gallium Phosphide
PG350	560	Super Pure Green	2.1	350mcd @ 20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
PG5	555	Pure Green	2.1	80mcd @ 20mA	15°	GaP/GaP - Gallium Phosphide/Gallium Phosphide
AG10K	525	Aqua Green	3.5	10,000mcd @ 20mA	15°	SiC/GaN - Silicon Carbide/Gallium Nitride
BG2K	505	Blue Green	3.5	2000mcd @ 20mA	45°	SiC/GaN - Silicon Carbide/Gallium Nitride
PB3K	470	Super Blue	3.6	3000mcd @ 20mA	15°	SiC/GaN - Silicon Carbide/Gallium Nitride
UB500	430	Ultra Blue	3.8	100mcd @ 20mA	15°	SiC/GaN - Silicon Carbide/Gallium Nitride

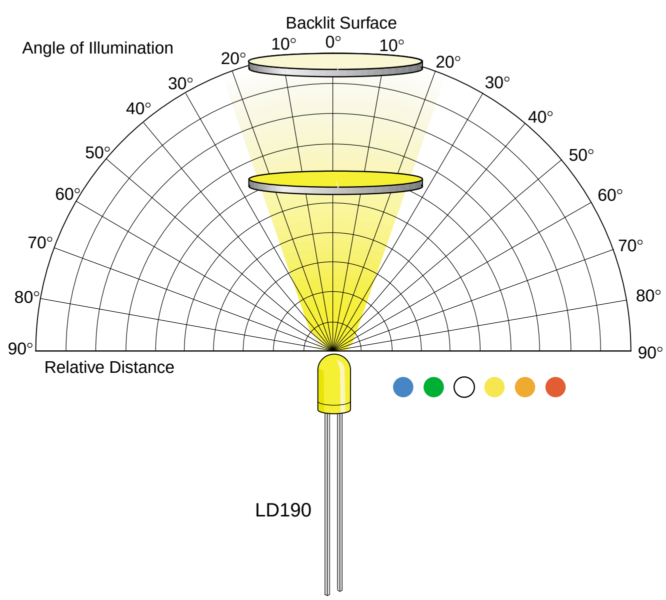
Backlighting Surfaces Using Discrete LEDs



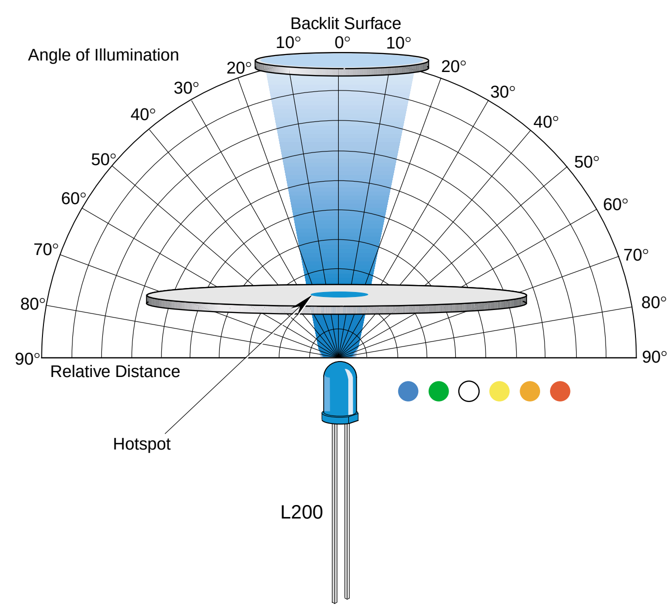
Extra wide illumination angle (160°)
Very short illumination distance



Wide illumination angle (120°)
Short illumination distance



Medium illumination angle (30° - 45°)
Medium illumination distance



Narrow illumination angle (8° - 20°)
Long illumination distance

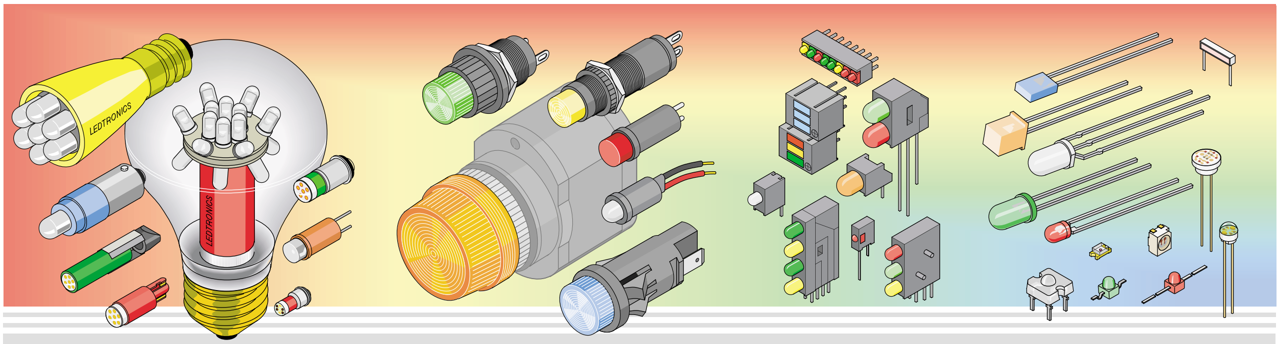
Discrete & SMT Ratings

Test Condition for Each Parameter

Parameter	Symbol	Unit	Test Condition
Reverse Voltage	V_r	V	–
Reverse Current	I_r	µA	V_r = 5.0 Volt
Forward Voltage	V_f	V	I_f = 20mA
Luminous Intensity	I_v	mcd	I_f = 10mA
Viewing Angle	2θ 1/2	Degree	I_f = 20mA
Spectral Line Half-Width	$\Delta\lambda$	nm	I_f = 20mA
Power Dissipation	Pd	mW	I_f = 20mA
Peak Forward Current (Duty 1/10 1KHz)	I_f(Peak)	mA	I_f(Peak) = 150mA
Capacitance	C	pF	V_f = 0,f = 1 MHz
Speed of Response	τ_s	ns	–
Thermal Resistance	Rθj-pin	°C/W	Junction to Cathode Lead

Absolute Maximum Ratings

Parameter	Test Condition
Reverse Voltage	5.0 Volt
Reverse Current (V_r = 5V)	≤100µA
Operating Temperature Range	–40°C ~ +80°C
Storage Temperature Range	–40°C ~ +85°C
LED Junction Temperature (Tj)	–



☐ Based LED ☐ Panel LED ☐ PCB LED ☐ Discrete LED

Name: ______________________ Title: ______________________

Company: ______________________ M/S: ______________________

Address: ____

City: ______________ State: ____ Zip: ________ Country: ____________

Phone: ______________ Fax: ____________ Email: ______________

Need Samples of: ____

More Info on: ____

My company produces: ____

Send copy of ☐ Based LED ☐ Panel LED ☐ PCB LED ☐ Discrete LED catalog

☐ Existing project ☐ New project ☐ Immediate need Budget approved ☐ Yes ☐ No

Current LEDs used: ____

Manufacturer: ____

Estimated yearly quantity: ____

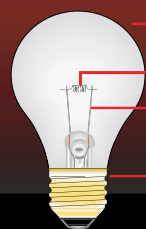
☐ Have Rep. call me ☐ Need pricing/Delivery

LEDTRONICS, INC.®

THE FUTURE OF LIGHT

23105 Kashiwa Court, Torrance, CA 90505
Phone: (800) 579-4875 or (310) 534-1505
E-mail: webmaster@ledtronics.com
Website: www.ledtronics.com
Fax: (310) 534-1424

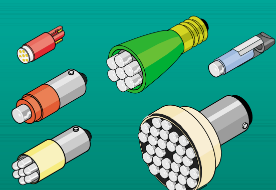
The Problem



The Solution

LEDTRONICS LED Lamp Advantages

- Epoxy and UV Stabilized Polycarbonate
- Solid-State LED Chip, No Fragile Filament
- Impervious to Electrical / Mechanical Shock and Vibration
- Uses 80% to 90% Less Power than Incandescent Bulbs
- 100,000 Hour Plus Life Span
- Available in All LED Colors: Red, Yellow, Orange, Green, Blue, Blue/Green, and White
- All Standard Electrical Bases and Voltages

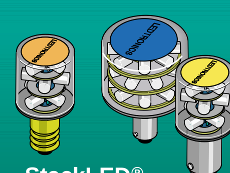


LED Lamps for All Applications

- Aviation/Aerospace
- Industrial motor controls
- Elevator
- Pilot lights
- Utility lamps
- Military

DécorLED

- Gaming casino & architectural lighting

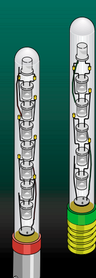


StackLED®

- Plant automation status indicator lamps

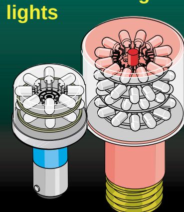
LED Exit Lamps

- Emergency lighting exit sign kits



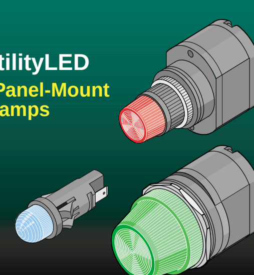
BeaconLED®

- Hazard working lights



UtilityLED

- Panel-Mount lamps



UT002 Rev. 4-2000

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23105 Kashiwa Court, Torrance, CA 90505
Phone: (800) 579-4875 or (310) 534-1505
Fax: (310) 534-1424
E-mail: webmaster@ledtronics.com
Website: www.ledtronics.com